Praseodymium-143 from Neutron-Irradiated Uranium

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From neutron-irradiated uranium cooled for about 2 days, $^{143}$Pr was separated indirectly by solvent extraction. After removing uranium and some extractable nuclides with bis(2-ethyl hexyl) orthophosphoric acid from 10 M nitric acid solution, $^{143}$Ce was extracted with bis(2-ethyl hexyl) orthophosphoric acid ($n$-heptane diluent) from a 10 M nitric acid solution containing potassium bromate. Then, $^{143}$Pr was purified after most of the $^{143}$Ce had decayed off. Detailed measurements indicated a half-life of 13.55 ±0.02 days and maximum $\beta$-ray energy of 0.93 ±0.05 MeV.

Ordinarily $^{143}$Pr is prepared from neutron-irradiated cerium target by solvent extraction, precipitation or ion exchange. $^{143}$Pr also exists in the fission products of uranium as the daughter of $^{143}$Ce ($t_{1/2}$=33 hr).

Peppard, et al.(1) reported the isolation of $^{143}$Pr from neutron-irradiated cerium and of $^{144}$Pr from a $^{144}$Ce-$^{144}$Pr mixture. The method is based upon the characteristic that Ce(IV) is preferentially extracted into bis(2-ethyl hexyl) orthophosphoric acid from 10 M HNO$_3$ and 1 M KBrO$_3$ solutions, while the distribution ratio of Pr is as low as about $10^{-3}$. McCown, et al.(2) applied this method to the separation of $^{144}$Ce from neutron-irradiated uranium cooled for about 90 days.

In this paper, the authors applied the same method to the isolation of $^{143}$Pr from neutron-irradiated uranium, according to the following procedure: Cerium containing $^{143}$Ce is separated from neutron-irradiated uranium, and the cerium fraction is stored until most of the $^{143}$Ce decays into its daughter, $^{143}$Pr. Then the $^{143}$Pr produced is separated from the cerium fraction which, besides $^{143}$Pr, contains $^{141}$Ce and $^{144}$Ce-$^{144}$Pr. The maximum $\beta$-ray energy and the half-life of the $^{143}$Pr thus separated is examined in detail.

EXPERIMENTAL

Uranium dioxide irradiated in JRR-1 for 5 hr with a neutron flux of about $5 \times 10^{12}$n/cm$^2$/sec and cooled for about 2 days was dissolved in 10 M HNO$_3$ solution. After first eliminating uranium and neptunium as well as some extractable nuclides with HDEHP (toluene diluent), $^{143}$Ce was separated from the fission products solution and purified with other cerium nuclides by Peppard’s procedure. The desired nuclide, $^{143}$Pr, was isolated from the cerium fraction after about 5 days standing, during which most of $^{143}$Ce decayed off. $^{143}$Pr thus obtained was further purified by TBP solvent extraction(3). The aliquots of the $^{143}$Pr solution were evaporated either on a platinum disc or on a thin Myler film to determine their half-life and $\beta$-ray energy. The $\beta$ activity was measured by a gas-flow end-window proportional counter, and the $\beta$-ray spectrum was obtained on a scintillation spectrometer with 1.5" x 0.5" anthracene crystal.

RESULTS

The maximum $\beta$-ray energy was determined by the Kurie plot presented in Fig. 1, which gave the value of 0.93±0.05 MeV. No $\gamma$-rays were detected from the sample. The decay curve presented in Fig. 2 was followed for about 10 half-lives but did not deviate from a straight line, and the half-life thus determined was 13.55±0.02 days. Since there was no evidence of any contamination from other fission products, it was thus proved that the Peppard’s procedure can be successfully applied to the separation of $^{143}$Pr from fission products, and the new half-life value (average value of three measurements) is very reli-

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able for $^{143}\text{Pr}$. The values obtained in this study are summarized in Table 1 together with reference values appearing in literature.

### Table 1 Values Half-life and $\beta$-energy of $^{143}\text{Pr}$

<table>
<thead>
<tr>
<th>Half-life (day)</th>
<th>$\beta$-energy (MeV)</th>
<th>Source</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
<td>13.55±0.02</td>
<td>0.93 ±0.05</td>
<td>Fission product</td>
<td>Present study</td>
</tr>
<tr>
<td>13.5 ±0.1</td>
<td>0.83</td>
<td>$^{144}\text{Ce}(d,n)^{143}\text{Pr}$</td>
<td>(4)</td>
</tr>
<tr>
<td>13.7 ±0.1</td>
<td>0.932±0.002</td>
<td>Oak Ridge Source</td>
<td>(5)</td>
</tr>
<tr>
<td>13.8</td>
<td>1.0</td>
<td>Fission product</td>
<td>(6)</td>
</tr>
<tr>
<td>13.76±0.05</td>
<td>0.920±0.010</td>
<td>$^{144}\text{Ce}(n,\gamma)^{144}\text{Ce}-^{143}\text{Pr}$</td>
<td>(7)</td>
</tr>
<tr>
<td>13.95</td>
<td>0.93 ±0.01</td>
<td>Fission product</td>
<td>(8)</td>
</tr>
<tr>
<td>13.59±0.04</td>
<td>—</td>
<td>$^{144}\text{Ce}(n,\gamma)^{144}\text{Ce}-^{143}\text{Pr}$</td>
<td>(9)</td>
</tr>
</tbody>
</table>

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**REFERENCES**